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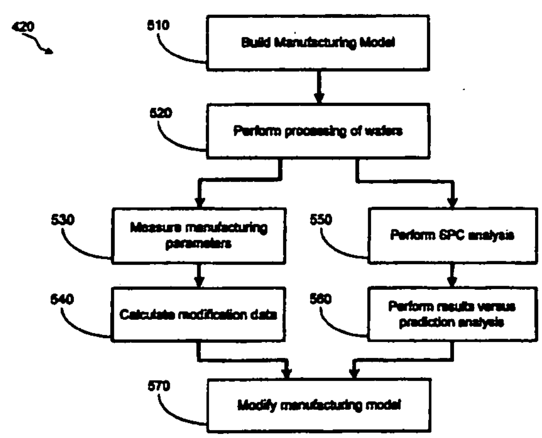
(54) Title: METHOD AND APPARATUS FOR MONITORING CONTROLLER PERFORMANCE USING STATISTICAL PROCESS CONTROL



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(57) Abstract: The present invention provides for a method and an apparatus for monitoring controller performance using statistical process control analysis. A manufacturing model (140) is defined. A processing run of semiconductor devices is performed as defined by the manufacturing model (140) and implemented by a process controller (610). A fault detection analysis is performed on the process controller (610). At least one control input signal generated by the process controller (610) is updated. The apparatus of the present invention comprises: a processing controller (610); a processing tool (620) coupled with the processing controller (610); a metrology tool (630) interfaced with the processing tool (620); a control modification data calculaton unit (640) interfaced with the metrology and connected to the processing controller (610) in a feedback manner; a predictor function (650) interfaced with the processing controller (610); a statistical process control analysis unit (660) interfaced with the predictor function (650) and the processing tool (620); and a results versus prediction analysis unit (670) interfaced with the statistical process control analysis unit (660) and connected to the processing controller (610) in a feedback manner.

METHOD AND APPARATUS FOR MONITORING CONTROLLER PERFORMANCE USING STATISTICAL PROCESS CONTROL

TECHNICAL FIELD

This invention relates generally to semiconductor products manufacturing, and, more particularly, to a method and apparatus for monitoring controller performance using statistical process control.

BACKGROUND ART

The technology explosion in the manufacturing industry has resulted in many new and innovative manufacturing processes. Today's manufacturing processes, particularly semiconductor manufacturing processes, call for a large number of important steps. These process steps are usually vital, and therefore, require a number of inputs that are generally fine tuned to maintain proper manufacturing control.

The manufacture of semiconductor devices requires a number of discrete process steps to create a packaged semiconductor device from raw semiconductor material. The various processes, from the initial growth of the semiconductor material, the slicing of the semiconductor crystal into individual wafers, the fabrication stages (etching, doping, ion implanting, or the like), to the packaging and final testing of the completed device, are so different from one another and specialized that the processes may be performed in different manufacturing locations that contain different control schemes.

Among the important aspects in semiconductor device manufacturing are RTA control, chemical-mechanical planarization (CMP) control , and overlay control. Overlay is one of several important steps in the photolithography area of semiconductor manufacturing. Overlay control involves measuring the misalignment between two successive patterned layers on the surface of a semiconductor device. Generally, minimization of misalignment errors is important to ensure that the multiple layers of the semiconductor devices are connected and functional. As technology facilitates smaller critical dimensions for semiconductor devices, the need for reduced of misalignment errors increases dramatically.

Generally, photolithography engineers currently analyze the overlay errors a few times a month. The results from the analysis of the overlay errors are used to make updates to exposure tool settings manually. Generally, a manufacturing model is employed to control the manufacturing processes. Some of the problems associated with the current methods include the fact that the exposure tool settings are only updated a few times a month. Furthermore, currently the exposure tool updates are performed manually. Many times, errors in semiconductor manufacturing are not organized and reported to quality control personal. Often, the manufacturing models themselves incur bias errors that could compromise manufacturing quality.

Generally, a set of processing steps is performed on a lot of wafers on a semiconductor manufacturing tool called an exposure tool or a stepper. The manufacturing tool communicates with a manufacturing framework or a network of processing modules. The manufacturing tool is generally connected to an equipment interface. The equipment interface is connected to a machine interface to which the stepper is connected, thereby facilitating communications between the stepper and the manufacturing framework. The machine interface can generally be part of an advanced process control (APC) system. The APC system initiates a control script based upon a manufacturing model, which can be a software program that automatically retrieves the data needed to execute a manufacturing process. Often, semiconductor devices are staged through multiple manufacturing tools for multiple processes, generating data relating to the quality of the processed semiconductor devices. Many times, errors in semiconductor manufacturing are not organized and reported to quality control personal, which can result in

reduced efficiency in manufacturing processes. Errors in the manufacturing model that is used to perform the manufacturing process, such as bias errors, often compromises the quality of manufactured products.

The present invention is directed to overcoming, or at least reducing the effects of, one or more of the problems set forth above.

DISCLOSURE OF INVENTION

In one aspect of the present invention, a method is provided for monitoring controller performance using statistical process control analysis. A manufacturing model is defined. A processing run of semiconductor devices is performed as defined by the manufacturing model and implemented by a process controller. A fault detection analysis is performed on the process controller. At least one control input signal generated by the process controller is updated.

In another aspect of the present invention, an apparatus is provided for monitoring controller performance using statistical process control analysis. The apparatus of the present invention comprises: a processing tool coupled with the processing controller; a metrology tool interfaced with the processing tool; a control modification data calculation unit interfaced with the metrology and connected to the processing controller in a feedback manner; a predictor function interfaced with the processing controller; an statistical process control analysis unit interfaced with the predictor function and the processing tool; and a results versus prediction analysis unit interfaced with the statistical process control analysis unit and connected to the processing controller in a feedback manner.

BRIEF DESCRIPTION OF THE DRAWINGS

The invention may be understood by reference to the following description taken in conjunction with the accompanying drawings, in which like reference numerals identify like elements, and in which:

Figure 1 illustrates one embodiment of the present invention;

Figure 2 illustrates a flowchart representation of one method of updating a manufacturing model;

Figure 3 illustrates a flowchart representation of the methods taught by the present invention;

Figure 4 illustrates a flowchart representation of a more detailed depiction of the step of performing fault detection on a run-to-run controller described in Figure 3;

Figure 5 illustrates a flowchart representation of a more detailed depiction of the step of performing process controller performance monitoring described in Figure 4; and

Figure 6 illustrates a block diagram representation of the apparatus taught by the present invention.

While the invention is susceptible to various modifications and alternative forms, specific embodiments thereof have been shown by way of example in the drawings and are herein described in detail. It should be understood, however, that the description herein of specific embodiments is not intended to limit the invention to the particular forms disclosed, but on the contrary, the intention is to cover all modifications, equivalents, and alternatives falling within the spirit and scope of the invention as defined by the appended claims.

MODE(S) FOR CARRYING OUT THE INVENTION

Illustrative embodiments of the invention are described below. In the interest of clarity, not all features of an actual implementation are described in this specification. It will of course be appreciated that in the development of any such actual embodiment, numerous implementation-specific decisions must be made to achieve the developers' specific goals, such as compliance with system-related and business-related constraints, which will vary from one implementation to another. Moreover, it will be appreciated that such a development

effort might be complex and time-consuming, but would nevertheless be a routine undertaking for those of ordinary skill in the art having the benefit of this disclosure.

There are many discrete processes that are involved in semiconductor manufacturing. Many times, semiconductor devices are stepped through multiple manufacturing process tools. As semiconductor devices are processed through manufacturing tools, production data, or manufacturing data, is generated. The production data can be used to perform fault detection analysis that can lead to improved manufacturing results. Overlay process is an important group of process steps in semiconductor manufacturing. In particular, overlay process involves measuring misalignment errors between semiconductor layers during manufacturing processes. Improvements in the overlay process could result in substantial enhancements, in terms of quality and efficiency, in semiconductor manufacturing processes. The present invention provides a method of acquiring production data and performing fault analysis on a process controller, such as a run-to-run controller, in response to the acquired production data.

Turning now to Figure 1, one embodiment of the present invention is illustrated. In one embodiment, semiconductor products 105, such as semiconductor wafers are processed on processing tools 110, 112 using a plurality of control input signals on a line 120. In one embodiment, the control input signals on the line 120 are sent to the processing tools 110, 112 from a computer system 130 via machine interfaces 115, 117. In one embodiment, the first and second machine interfaces 115, 117 are located outside the processing tools 110, 112. In an alternative embodiment, the first and second machine interfaces 115, 117 are located within the processing tools 110, 112.

In one embodiment, the computer system 130 sends control input signals on a line 120 to the first and second machine interfaces 115, 117. The computer system 130 employs a manufacturing model 140 to generate the control input signals on the line 120. In one embodiment, the manufacturing model 140 defines a process script and input control that implement a particular manufacturing process. The control input signals on a line 120 that are intended for processing tool A 110 are received and processed by the first machine interface 115. The control input signals on a line 120 that are intended for processing tool B 112 are received and processed by the second machine interface 117. Examples of the processing tools 110, 112 used in semiconductor manufacturing processes are steppers.

For processing tools such as steppers, the control inputs, on the line 120, that are used to operate the processing tools 110, 112 include an x-translation signal, a y-translation signal, an x-expansion wafer scale signal, a y-expansion wafer scale signal, a reticle magnification signal, and a reticle rotation signal. Generally, errors associated with the reticle magnification signal and the reticle rotation signal relate to one particular exposure process on the surface of the wafer being processed in the exposure tool. One of the primary features taught by the present invention is a method of detecting and organizing fault data for semiconductor manufacturing processes.

For photolithography processes, when a process step in a processing tool 110, 112 is concluded, the semiconductor product 105 or wafer that is being processed is examined in a review station. One such review station is a KLA review station. One set of data derived from the operation of the review station is a quantitative measure of the amount of misregistration that was caused by the previous exposure process. In one embodiment, the amount of misregistration relates to the misalignment in the process that occurred between two layers of a semiconductor wafer. In one embodiment, the amount of misregistration that occurred can be attributed to the control inputs for a particular exposure process. The control inputs generally affect the accuracy of the process steps performed by the processing tools 110, 112 on the semiconductor wafer. Modifications of the control inputs can be utilized to improve the performance of the process steps employed in the manufacturing tool. Many times,

the errors that are found in the processed semiconductor products 105 can be correlated to a particular fault analysis and corrective actions can be taken to reduce the errors.

Turning now to Figure 2, a flowchart representation of one embodiment of a process for updating the manufacturing model 140 is illustrated. In one embodiment, the manufacturing model 140 that is used by a process controller, such as an Advanced Process Control (APC) system, is defined, as described in block 210 of Figure 2. Once the manufacturing model 140 is defined, a manufacturing run of semiconductor devices, such as semiconductor wafers, is performed, as described in block 220 of Figure 2. When the manufacturing run of semiconductor wafers is complete, a set of production data is collected, including measuring a plurality of wafer parameters, as described in block 230 of Figure 2. The wafer parameters include misalignment and misregistration errors during photolithography processes. The wafer parameters also include measuring post-polish thickness errors during a polishing process.

In one embodiment, the production data is used to update the manufacturing model 140, which is used by the process controller to modify control input signals for a subsequent manufacturing run of semiconductor wafers, as described in block 240 of Figure 2. The run-to-run controller then implements the next manufacturing run of semiconductor wafers and the feedback process is repeated as illustrated in Figure 2. In general, an ideal manufacturing model 140 would result in random production errors that are distributed evenly over a Guassian-type error curve. However, due to the non-ideal characteristics of manufacturing models 140, non-random errors could occur. An error bias can develop within the manufacturing model resulting in consistent errors during semiconductor manufacturing.

In some manufacturing processes, there are over 300 process steps that are defined by a manufacturing model 140 and are implemented on a semiconductor wafer. A change in any one of the process steps can affect other related process steps such that the manufacturing model 140 that defines the process steps can become inaccurate. In some cases a chain reaction in the production of semiconductor wafers caused by a change in a particular process step can cause the manufacturing model 140 to no longer describe the process steps well, causing errors in production. In other words, a bias is created in the manufacturing model 140 such that now there is a consistent defect in the processed semiconductor wafers. For example, if the original manufacturing model was designed to generate semiconductor wafers with zero overlay error, a bias in the manufacturing model 140 can cause a 10 micro-meter misalignment error in every semiconductor wafer that is processed under the control of the manufacturing model 140. In other words, there is noise in the manufacturing system that is implementing the manufacturing model 140 that causes non-random errors that are outside a normal Guassian error curve.

Furthermore, the aging of a manufacturing model 140 may cause degradation of output products that are manufactured within a manufacturing model 140 structure. In other words, gradually over time, a manufacturing model 140 can change its prior behavior. One example of aging of a manufacturing model 140 is degradation of lamps in an exposure tool. Implementation of the methods taught by the present invention can reduce the effects of aging of manufacturing models 140. The present invention teaches a method of implementing a statistical process control analysis method for reducing the bias and noise in manufacturing systems.

In one embodiment, statistical process control (SPC) is a method of monitoring, controlling, and, ideally, improving a process through statistical analysis. In one embodiment, SPC analysis is comprised of four main steps. The main steps of SPC analysis include measuring the process, reducing variances in the process to make the process more consistent, monitoring the process, and improving the process to produce its best value. In real-time SPC, which can be used for run-to-run control applications in one embodiment, data is collected from the

most recently finished manufacturing run of semiconductor wafers before the next manufacturing run of semiconductor wafers is processed. Steps are taken to ensure that the quality of the processed semiconductor wafers are as consistent as possible from one manufacturing run to another. Generally, SPC analysis rules dictate that causes of errors discovered during one manufacturing run of semiconductor wafers must be corrected before the next manufacturing run of semiconductor wafers is performed.

Turning now to Figure 3, a flowchart depiction of one embodiment of the present invention is illustrated. In one embodiment, a manufacturing model 140 that is used by a process controller, such as an Advanced Process Control (APC) system, is defined, as described in block 310 of Figure 3. Once the manufacturing model 140 is defined, a manufacturing run of semiconductor devices, such as semiconductor wafers, is performed, as described in block 320 of Figure 3. When a manufacturing run of semiconductor wafers is completed, a fault detection analysis is performed on the process controller, as described in block 330 of Figure 3. In one embodiment, the fault detection analysis is performed on a process controller that is a run-to-run controller. A more detailed depiction of the step of performing fault detection analysis, described in block 330 of Figure 3, is illustrated in Figure 4.

Turning now to Figure 4, after a manufacturing run of semiconductor wafers is completed, the corresponding production data is acquired, as described in block 410 of Figure 4. The production data that is acquired includes misalignment errors, misregistration errors, critical dimension errors, polishing thickness errors, and the like. Once production data is acquired, a process controller performance monitoring step is performed, as described in block 420 of Figure 4. A more detailed depiction of the step of performing process controller performance monitoring described in block 420 of Figure 4, is illustrated in Figure 5.

Turning now to Figure 5, one embodiment of performing process controller performance monitoring is illustrated. In one embodiment, a manufacturing model 140 that is used by a process controller is defined, as described in block 510 of Figure 5. Subsequently, semiconductor wafers are processed using the manufacturing model, as described in block 520 of Figure 5. Once a set of semiconductor wafers is processed, manufacturing parameters, such as production data, are measured, as described in block 530 of Figure 5. The manufacturing parameters that are measured include misalignment errors, misregistration errors, critical dimension errors, and polishing thickness error. In one embodiment, manufacturing parameters are measured using metrology tools.

Once the manufacturing parameters are measured, modification data is calculated for modifying parameters defined by the manufacturing model 140, as described in block 540 of Figure 5. Concurrently, SPC analysis, which is described above, is performed after processing of semiconductor wafers, as described in block 550 of Figure 5. In one embodiment, while performing SPC analysis, a prediction is made regarding the expected process behavior for a particular manufacturing model 140. After processing a set of semiconductor wafers, the results from analysis of the semiconductor wafers is compared with the predicted process behavior, as described in block 560 of Figure 5. In other words, a judgment is made regarding how different the actual results from a processing step are from a set of predicted results for that processing step. In one embodiment, standard SPC calculation methods that are known to those skilled in the art, and having the benefit of the present disclosure, are employed for SPC analysis for the present invention.

The difference between the predicted process results and the actual process results is used to determine whether the manufacturing model 140 should be modified for the next manufacturing run of semiconductor wafers, thereby performing fault detection upon a run-to-run controller. Using results obtained by measuring manufacturing parameters and performing SPC analysis, the manufacturing model 140 is then modified to be used

for subsequent manufacturing processes, as described in block 570 of Figure 5. The modification of the manufacturing model 140 described in block 570 completes the step of performing process control performance monitoring that is described in block 420 of Figure 4.

Turning back to Figure 4, once the manufacturing model 140 is modified, the modified manufacturing model 140 is implemented into the process controller that controls subsequent processing of semiconductor devices, as described in block 430 of Figure 4. Modification factors needed to make modification to the control input signals on the line 120 are calculated, as described in block 440 of Figure 4. The completion of the calculations described in block 440 of Figure 4 completes the step of performing fault detection analysis on the process controller that is described in block 330 of Figure 3. Turning back to Figure 3, once calculations for modifying control input signals are made, the control input signal on the line 120 are modified to be used for a subsequent manufacturing run of semiconductor wafers, as described in block 340 of Figure 3.

Turning now to Figure 6, one embodiment of the apparatus for implementing the principles taught by the present invention is illustrated. An inner feedback loop is created between a processing controller 610, a processing tool 620, a metrology tool 630, and a control modification data calculation unit 640. The processing controller 610 is interfaced with the processing tool 620. In one embodiment, the processing controller 610 calculates and sends control input signals that control the function of the processing tool 620. The processing tool 620 is interfaced with the metrology tool 630, which performs measurement of manufacturing parameters on semiconductor wafers that are processed by the processing tool 620.

The metrology tool 630 is interfaced with the control modification data calculation unit 640. The control modification data calculation unit 640 uses data provided by the metrology tool 630 to perform calculations for the modification of control input signals that are generated by the processing controller 610. In one embodiment, the control modification data calculation unit 640 is a computer program that is interfaced with the processing controller 610. Data from the control modification data calculation unit 640 is utilized by the processing controller 610 to modify control input signals that are sent to the processing tool 620 for a subsequent processing of semiconductor wafers.

Concurrently, an outer feedback is created between the processing controller 610, the processing tool 620. the predictor function 650, the SPC analysis unit 660, and the results versus prediction analysis unit 670. The predictor function 650 is interfaced with the processing controller 610 and predicts an expected result of a manufacturing run of semiconductor wafers, based on the control input signals generated by the processing controller 610. In one embodiment, the predictor function 650 is a computer program and is located within a manufacturing model 140. Data from the processed semiconductor wafers is used by the SPC analysis unit 660 to perform SPC analysis. In one embodiment, the SPC analysis unit 660 is a computer program that is interfaced with the manufacturing model 140. The results versus prediction analysis unit 670 calculates the differences between the predicted results of a manufacturing run of semiconductor wafers and the actual results of a manufacturing run of semiconductor wafers. In one embodiment, the results versus prediction analysis unit 670 is a computer program. The data calculated by the results versus prediction analysis unit 670 is used by the processing controller 610 to modify control input signals for a subsequent manufacturing run of semiconductor wafers that is performed by the processing tool 620. The principles taught by the present invention can be implemented into other types of manufacturing frameworks.

The principles taught by the present invention can be implemented in an Advanced Process Control (APC) Framework. The APC is a preferred platform from which to implement the overlay control strategy taught by the

present invention. In some embodiments, the APC can be a factory-wide software system, therefore, the control strategies taught by the present invention can be applied to virtually any of the semiconductor manufacturing tools on the factory floor. The APC framework also allows for remote access and monitoring of the process performance. Furthermore, by utilizing the APC framework, data storage can be more convenient, more flexible, and less expensive than local drives. The APC platform allows for more sophisticated types of control because it provides a significant amount of flexibility in writing the necessary software code.

Deployment of the control strategy taught by the present invention onto the APC framework could require a number of software components. In addition to components within the APC framework, a computer script is written for each of the semiconductor manufacturing tools involved in the control system. When a semiconductor manufacturing tool in the control system is started in the semiconductor manufacturing fab, it generally calls upon a script to initiate the action that is required by the process controller, such as the overlay controller. The control methods are generally defined and performed in these scripts. The development of these scripts can comprise a significant portion of the development of a control system.

The particular embodiments disclosed above are illustrative only, as the invention may be modified and practiced in different but equivalent manners apparent to those skilled in the art having the benefit of the teachings herein. Furthermore, no limitations are intended to the details of construction or design herein shown, other than as described in the claims below. It is therefore evident that the particular embodiments disclosed above may be altered or modified and all such variations are considered within the scope and spirit of the invention. Accordingly, the protection sought herein is as set forth in the claims below.

CLAIMS

1. A method for monitoring controller performance using statistical process control analysis, comprising:

defining a manufacturing model (140);

performing a processing run of semiconductor devices as defined by said manufacturing model (140) and implemented by a process controller (610);

performing a fault detection analysis on said process controller (610); and

updating at least one control input signal generated by said process controller (610).

2. The method described in claim 1, wherein performing a fault detection analysis on said process controller (610) further comprises:

acquiring production data;

performing process controller (610) performance monitoring using said production data;

modifying said manufacturing model (140) in response to said process controller (610) performance monitoring; and

implementing said modified manufacturing model (140) in said process controller (610);

3. The method described in claim 2, wherein acquiring production data further comprises acquiring metrology data using a metrology tool (630).

4. The method described in claim 2, wherein performing process controller (610) performance monitoring using said production data further comprises:

measuring manufacturing parameters;

calculating modification data based upon said manufacturing parameters;

performing statistical process control analysis;

performing results versus prediction analysis based upon said statistical process control analysis; and

modifying said manufacturing model (140) based upon said calculated modification data and said results versus prediction analysis.

5. The method described in claim 4, wherein performing results versus prediction analysis further comprises comparing a predicted manufacturing process behavior to a result of a measured manufacturing process.

6. An apparatus for monitoring controller performance using statistical process control analysis, CHARACTERIZED IN THAT,

the apparatus includes:

a processing controller (610);

a processing tool (620) coupled with said processing controller (610);

a metrology tool (630) interfaced with said processing tool (620);

a control modification data calculation unit (640) interfaced with said metrology and connected to said processing controller (610) in a feedback manner;

a predictor function (650) interfaced with said processing controller (610);

a statistical process control analysis unit (660) interfaced with said predictor function (650) and said processing tool (620); and

a results versus prediction analysis unit (670) interfaced with said statistical process control analysis unit (660) and connected to said processing controller (610) in a feedback manner.

7. The apparatus described in claim 6, wherein said processing controller (610) is a run-to-run controller.

8. The apparatus described in claim 6, wherein said processing controller (610) an automatic process control (APC) system.

9. The apparatus described in claim 6, wherein said control modification data calculation unit (640) is a computer software program integrated into said processing controller (610).

10. An apparatus for monitoring controller performance using statistical process control analysis, comprising:

means for defining a manufacturing model (140);

means for performing a processing run of semiconductor devic`es as defined by said manufacturing model (140) and implemented by a process controller (610);

means for performing a fault detection analysis on said process controller (610); and

means for updating at least one control input signal generated by said process controller (610).

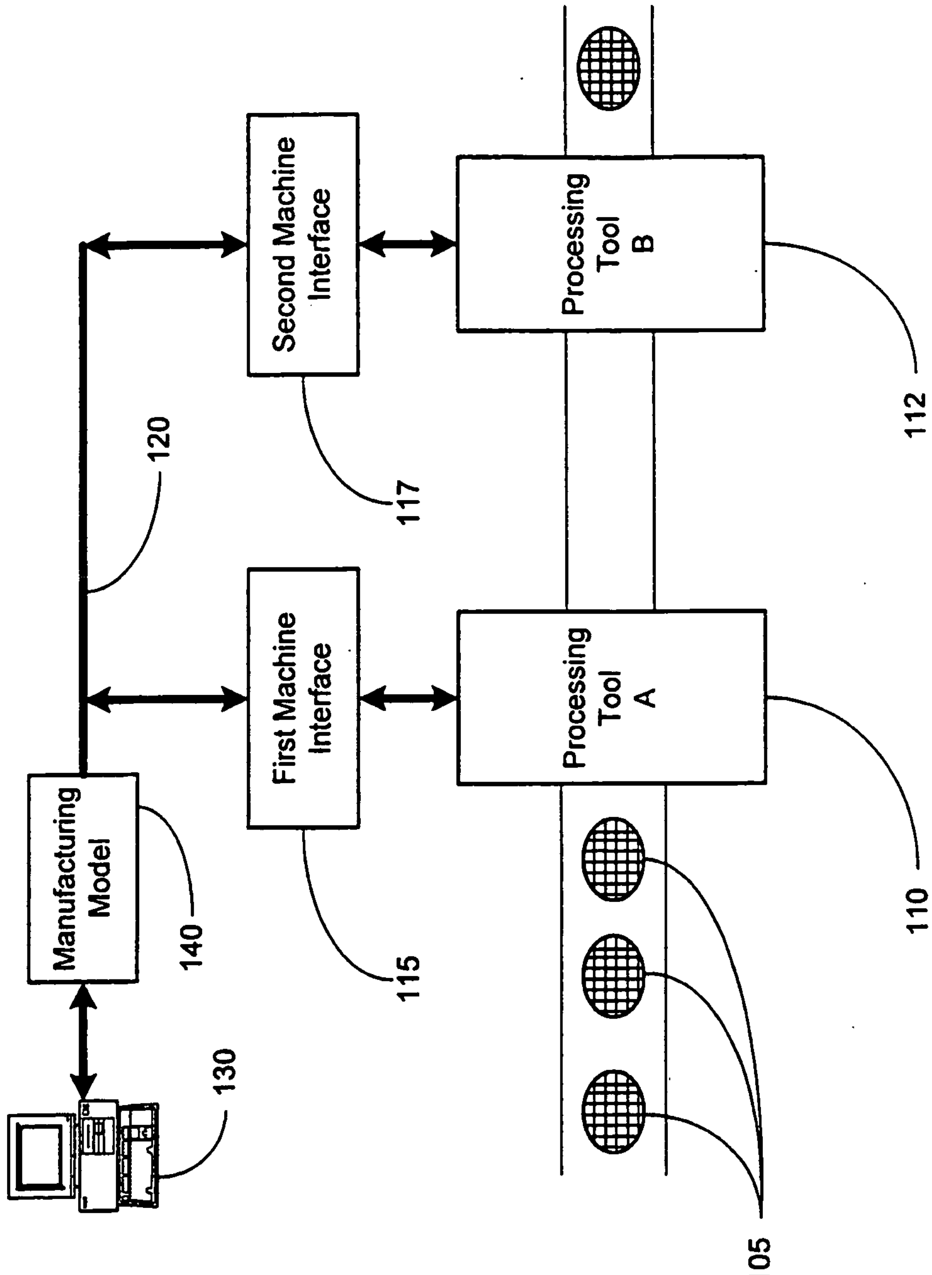
Manufacturing Model
First Machine Interface
Second Machine Interface
Processing Tool A
Processing Tool B
105
110
112
115
117
120
130
140

FIGURE 1

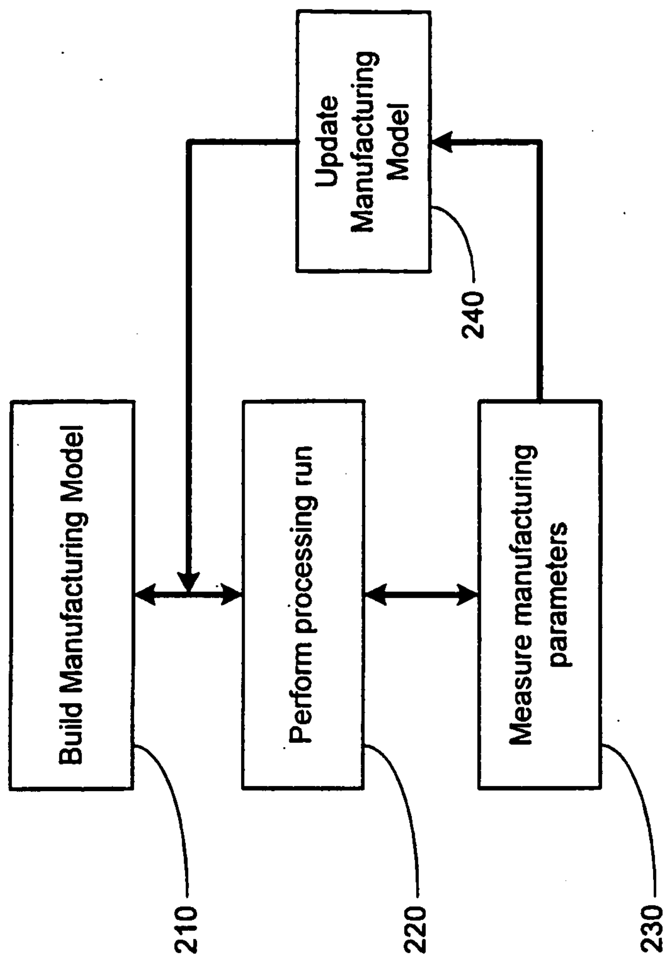
Build Manufacturing Model
Perform processing run
Measure manufacturing parameters
Update Manufacturing Model
210
220
230
240

FIGURE 2

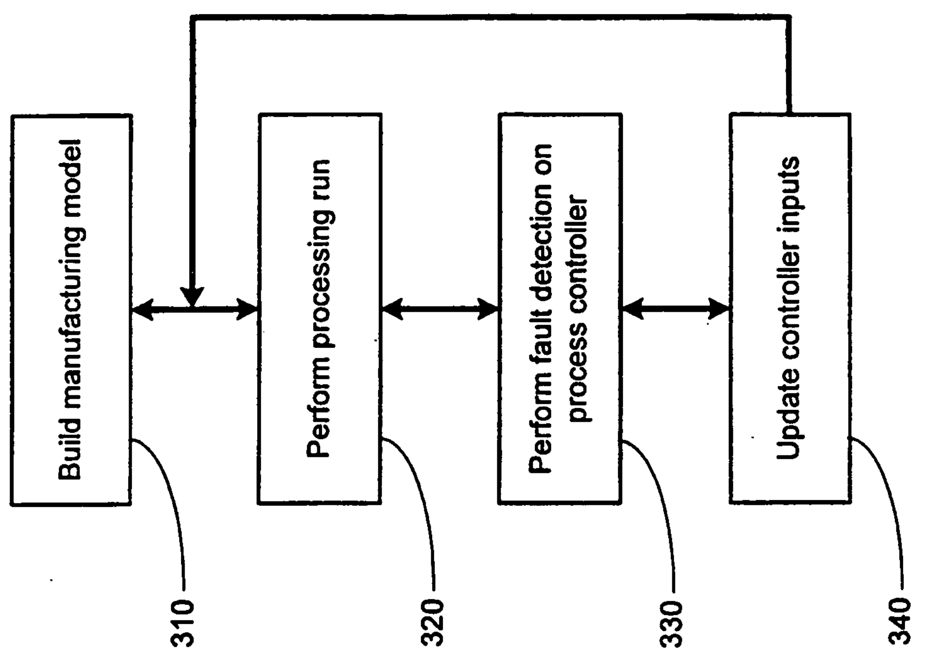
Build manufacturing model
Perform processing run
Perform fault detection on process controller
Update controller inputs
310
320
330
340

FIGURE 3

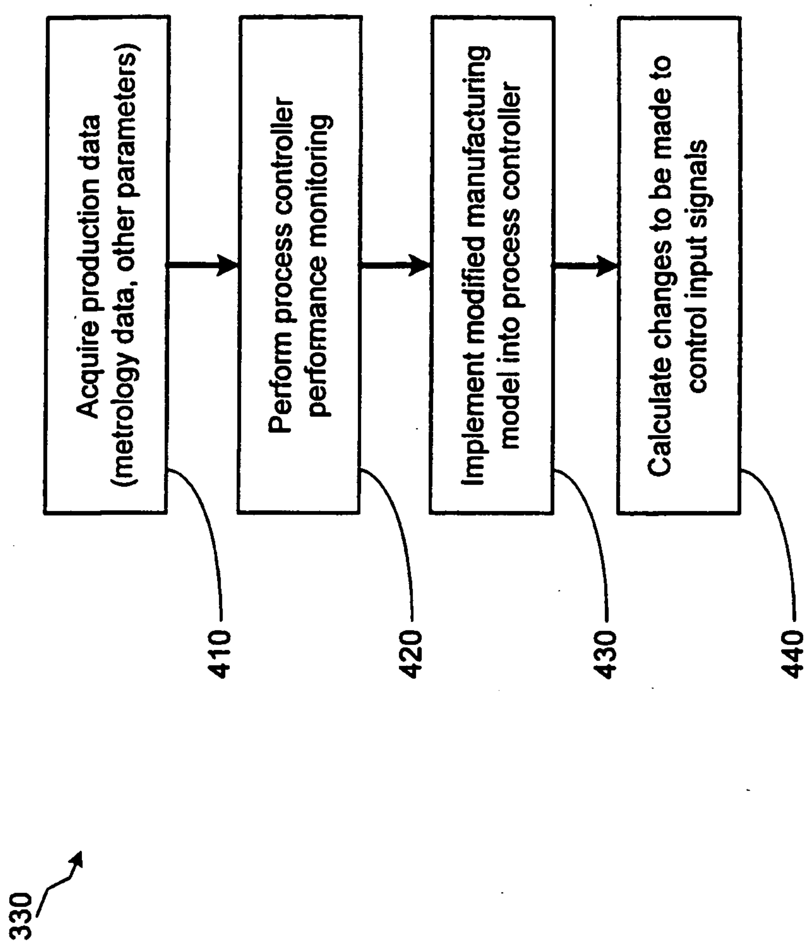
Acquire production data (metrology data, other parameters)
Perform process controller performance monitoring
Implement modified manufacturing model into process controller
Calculate changes to be made to control input signals
410
420
430
440
330

FIGURE 4

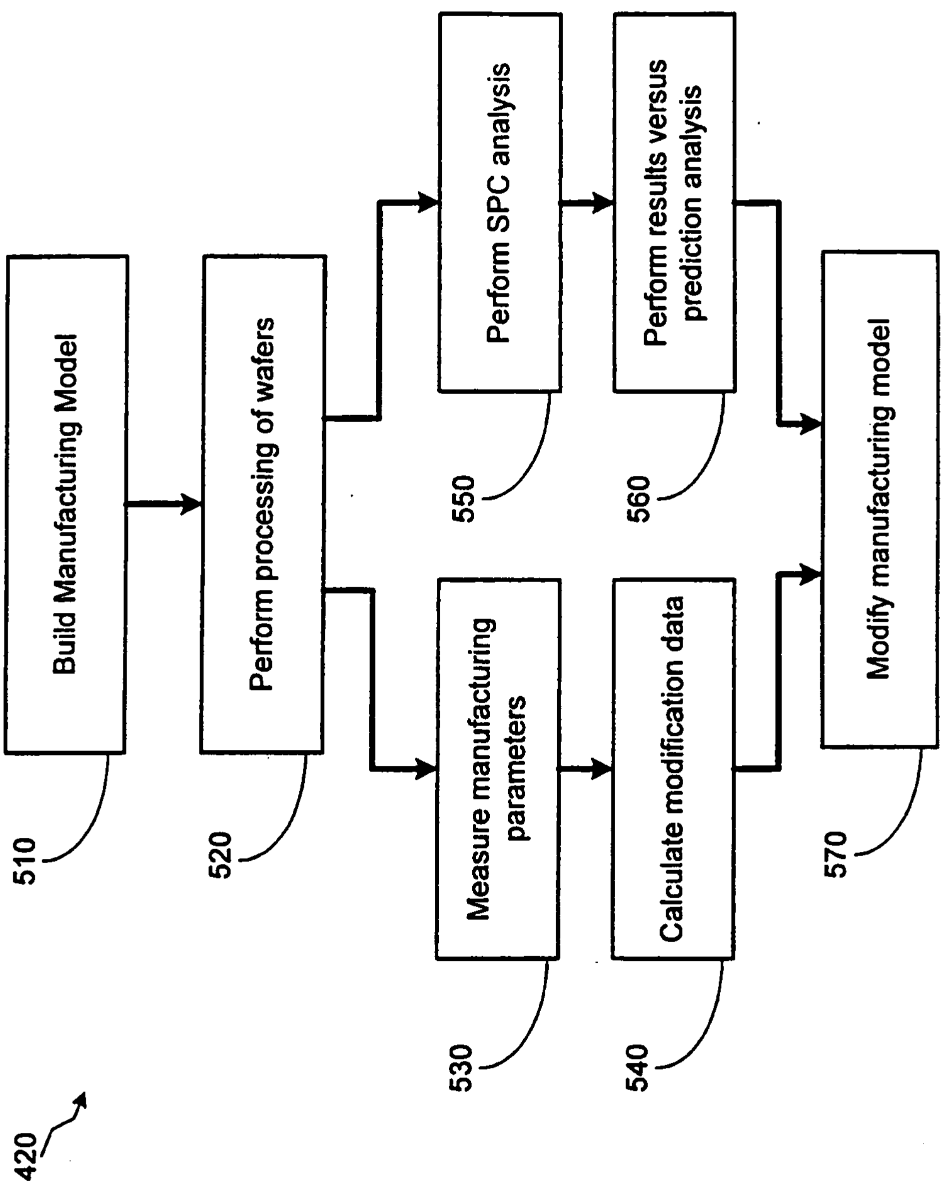
420
510
Build Manufacturing Model
520
Perform processing of wafers
530
Measure manufacturing parameters
540
Calculate modification data
550
Perform SPC analysis
560
Perform results versus prediction analysis
570
Modify manufacturing model

FIGURE 5

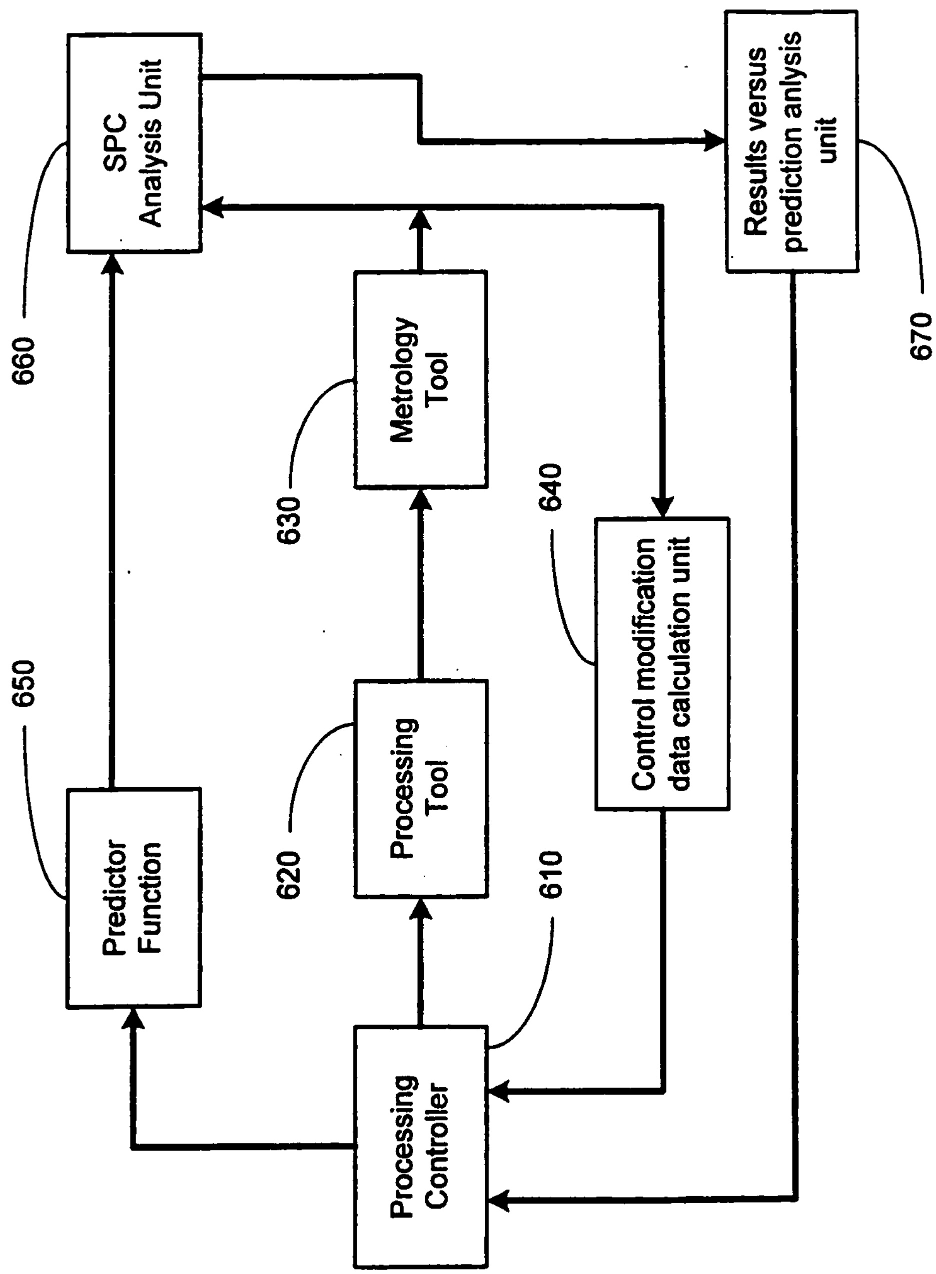
SPC Analysis Unit
Results versus prediction anlysis unit
Metrology Tool
Control modification data calculation unit
Processing Tool
Predictor Function
Processing Controller
610
620
630
640
650
660
670

FIGURE 6

INTERNATIONAL SEARCH REPORT

Inten nal Application No
PCT/US 00/11522

A. CLASSIFICATION OF SUBJECT MATTER
IPC 7 G05B19/418

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC 7 G05B

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

EPO-Internal, WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X,P	WO 00 00874 A (ADVANCED MICRO DEVICES INC) 6 January 2000 (2000-01-06) page 5 -page 11; figures 2,3	1-10
X,P	US 5 987 398 A (CHOU YOUN-MIN ET AL) 16 November 1999 (1999-11-16) column 4, line 51 -column 8, line 9; figure 8	1-6,10
X	US 5 661 669 A (MOZUMDER PURNENDU KANTI ET AL) 26 August 1997 (1997-08-26) column 3, line 12 -column 6, line 44; figures 1,2	1-10
X	US 5 546 312 A (MOZUMDER PURNENDU K ET AL) 13 August 1996 (1996-08-13) column 4, line 8 -column 10, line 12; figure 5	1-10

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[X] Further documents are listed in the continuation of box C.

[X] Patent family members are listed in annex.

° Special categories of cited documents :

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"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
22 August 2000	05/09/2000

Name and mailing address of the ISA	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Tx. 31 651 epo nl, Fax: (+31-70) 340-3016	Tran-Tien, T

1

INTERNATIONAL SEARCH REPORT

International Application No
PCT/US 00/11522

C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 5 452 218 A (TUCKER MARVIN G ET AL) 19 September 1995 (1995-09-19) column 1, line 58 -column 6, line 62; figures 1-4	1-10
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INTERNATIONAL SEARCH REPORT

Information on patent family members

International Application No
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Chemical mechanical polishing device with terminal point detection functions

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Abstract

The present invention provides a method for detecting the end point in a chemical mechanical polishing (CMP) process, which uses a multi-frequency-band light as an interference light source capable of expanding the detection range of the polishing thickness. In a CMP process, a multi-frequency-band light source emits lights with several wavelength. Each light with a different wavelength is reflected once on the upper and lower surfaces of the polishing layer. The interference phenomena formed by the reflected light is received by a detector. The intensity of the signals received by the detector is the accumulated sum of individual interference signals. Its period is the least common multiple of the period of all individual interference signals. A predetermined theoretical calculation or an experimental method is used to obtain the relationship data of the total interference intensity relative to the film thickness. This relationship data is used as a reference value to determine the time to terminate a CMP process.

